

# Investigating the Interrelationship between Undergraduates' Digital Literacy and Self-Regulated Learning Skills

*Research-in-Progress*

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## Abstract

*Advances in technology access allow undergraduates to personalize their learning to their individual interests via the creation and use of informal personal learning environments (PLEs). A comprehensive understanding of how every day digital technologies are adapted and used to create such PLEs and their impact on acquisition and development of students' digital literacy (DL) and self-regulated learning (SRL) skills, is still lacking. This paper presents the initial phase of an extensive mixed methods study to identify and describe the interrelationship between DL and SRL skills of students, when using PLEs. Our expected contribution to Information Systems theory and practice is to clarify the manner in which students develop and foster DL skills via the informal use of technology for learning purposes and the resultant impact on their SRL skills. We hope to create a more precise picture of the patterns and contexts of technology adoption for learning, via empirical evidence.*

**Keywords:** Digital Literacy, Self-regulated learning, Personal learning environments

## Introduction

Learning is increasingly viewed as a personalized, social, open, emergent and knowledge-pull activity, as opposed to the more traditional learning models of the one-size-fits-all, centralized, top-down, and knowledge-push conception (Chatti et al. 2010). Advances in technology access allows learners to customize their learning to their personal interest via the construction of technology based informal personal learning environments (PLE) (Tausend 2013). Ubiquitous access to 'everyday digital technologies' (Vivian and Barnes 2010) including social or entertainment technology (such as web 2.0 tools), digital media tools, programming tools, software applications and all manner of digital devices enables technology to be seamlessly incorporated in to the lives of current undergraduate students (Ensminger and Lewis 2011; Siemens et al. 2015)

Past research shows that students are accessing a plethora of information via online search in various formats such as text and multimedia, using informal and formal social networks such as Facebook and LinkedIn to connect with friends and peers to supplement learning, collecting and sharing information and artifacts via file sharing and synchronization tools such as Evernote and Dropbox and discussing and reflecting on information collaboratively using a multitude of internet based communication tools. Thereby creating customized PLEs, comprised of a wide range of freely available tools and services accessible on their everyday devices, as a strategy for learning informally. Components and content of this PLE is changed to fit individual learning needs (Conole 2012; Mohd and Shahbodin 2015), rarely limiting to a single technology or even device in order to engage in learning (Tess 2013; Johnson et al. 2015).

There is an increasing interest in studying PLEs as an environment created by students, to access many of their learning needs on their own using tools and technologies of their choice (Fiedler and Våljataga 2011; Pettenati 2010). There is scope for further consideration of aspects such as, the informal learning opportunities afforded by the combined use of various tools and technologies to construct a PLE (Keppell 2015), the implications of consistently using customized PLEs alongside the institutional LMS's in a seamless manner together with the resultant impact on their digital skills (Liew and Kang 2012) and how learning actually takes place when students select their own digital technologies to engage in informal learning activities initiated and controlled purely by them (Balcikanli 2012; Dahlstrom and Bichsel 2014; Kabilan et al. 2010; Lowe and Laffey 2011).

Therefore, the objective of this study is to identify, understand and describe how undergraduate students are using and adapting everyday digital technologies for creating informal PLEs and the resultant impact on their skills.

Moreover, the concept of creating and using a PLE is in tandem with the theoretical perspective of recognizing the importance of students taking responsibility for the organization and management of their own learning (Costa et al. 2010), demonstrating cognizance of one's learning process and requirements, recognizing existing opportunities and overcoming obstacles in order to learn successfully (Melzer and Schoop 2015). This, is synonymous with the concept of self-regulated learning (SRL) (Zimmerman 2000), a set of skills consistently acknowledged to be fostered with and through the use of technology (Steffens and Underwood 2008; Dettori and Persico 2010).

SRL comprises an essential aspect of the PLE (Mikroyannidis and Connolly 2012). Research also indicates that the creation and use of a PLE allows learners to regulate their own learning, thereby significantly enhancing their learning outcomes (Fruhmann et al. 2010; Steffens 2007).

Likewise, PLEs are regarded as a context of developing a working knowledge of digital technology and understanding of how it can be effectively used for educational purposes. i.e. 'Digital Literacy' (DL) skills (Laakkonen and Taalas 2015). There is some disagreement among researchers about current university students' levels of digital literacy (Bullen et al. 2011; Margaryan et al. 2011). It is acknowledged, however, that the lack of digital literacy skills could impact learning skills and performance of students (Atkins et al. 2013).

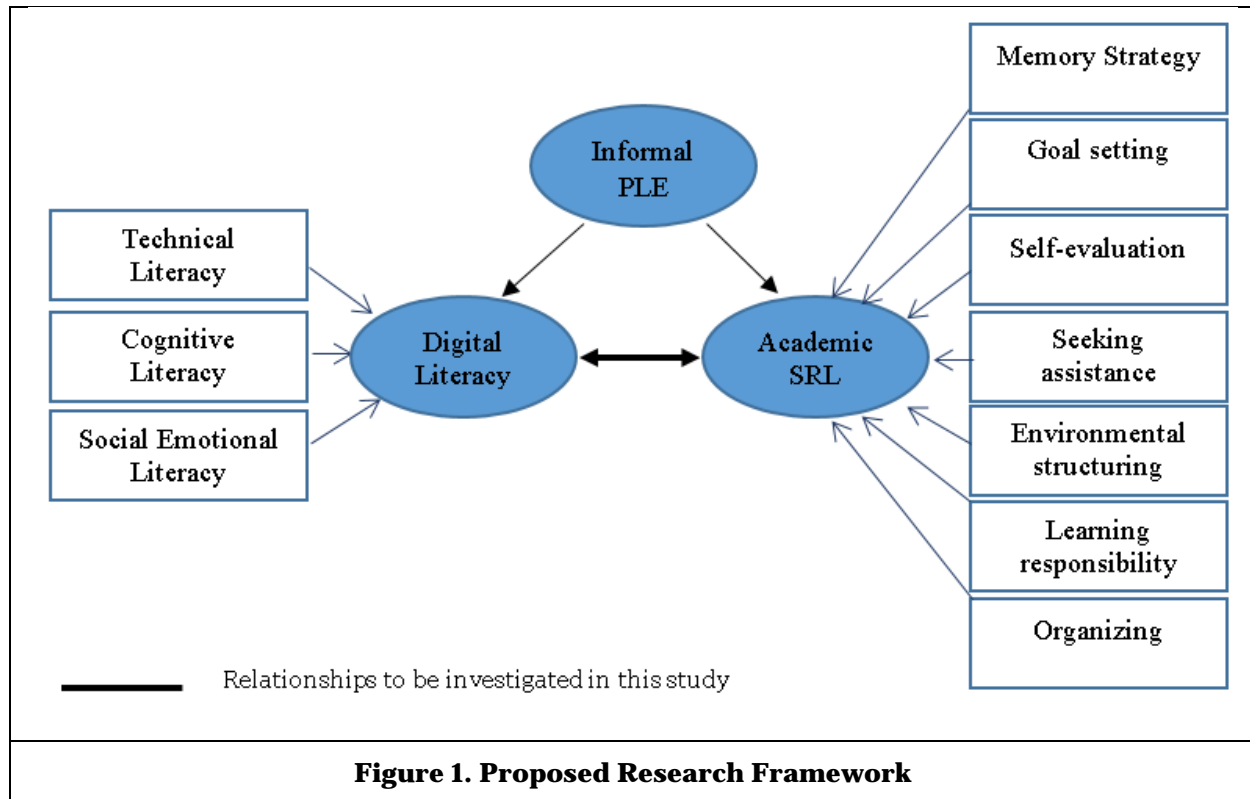
For example, a student attempting to use online search tools of his/her PLE for accessing information should be able to effectively plan the search task while demonstrating an ability to monitor and evaluate the impact of the search on the required learning. These are some component skills of SRL. Similarly, the student should also demonstrate an ability to competently use the search tools, while being knowledgeable of issues related to web based activities such as plagiarism. These are aspects of DL. Without successfully applying both skill sets the student would not be able to complete the search task effectively.

Moreover, previous research posits a positive correlation between DL and SRL skills of learners (Yang and Kim 2014) and that DL requires effective SRL (Greene et al. 2014).

Following a similar line of reasoning, we suggest the further examination of these interrelationships between DL, SRL and informal PLEs via a broad mixed methods study. The specific aim of this paper is to investigate the interrelationship between DL and academic SRL skills of undergraduates within the context of their technology based informal PLEs.

This paper presents one component of a proposed larger study, and attempts the investigation of DL and SRL via their operationalization presented in Figure 1 below.

We suggest that DL skill levels of undergraduate students have a positive effect on their academic SRL behaviors and that academic SRL skills among students would impact their working knowledge and adoption of technology for educational purposes.



The guiding mixed methods research question (RQ) for the study presented in this paper is as follows:

*RQ. To what extent and in what ways are the digital literacy skill levels of undergraduate students and their self-regulated learning skills interrelated?*

In the quantitative phase of investigating this RQ, it is hypothesized that there is a significant bidirectional relationship between the digital literacy skill levels of undergraduate students and their academic self-regulatory learning skills.

The focal objective for the qualitative phase, in investigating this RQ, is to explore and explain how the acquisition and use of technology within an informal PLE influences the development of digital literacy skill and SRL strategies of undergraduates.

In answering this research question, and our completed research, we expect to contribute to the IS literature by providing insight on how undergraduates develop and foster digital literacy skills via the informal use of technology for learning purposes. We hope to clarify how academic self-regulatory behaviors could vary as a result of interaction with technology for learning and digital skills developed herein.

A further contribution is to create a more precise picture of the patterns and contexts of technology adoption by university students via empirical evidence, specifically to understand and describe how technological adoption in learning settings can improve self-regulated learning.

In the subsequent sections relevant literature on PLE, DL and SRL within the context of informal learning is reviewed followed by a discussion of the proposed research method to be employed in this study. The paper concludes with a discussion of its expected contributions and directions for future research.

## **Theoretical Background**

This section elaborates on the constructs of PLE, DL and SRL, and discusses the context for the interrelationship between these constructs via recent literature.

### ***Personal Learning Environments (PLE)***

Personal learning environments (PLEs) are characterized as "... an approach in Technology-Enhanced Learning (TEL) based on the principles of learner autonomy, ownership and empowerment" (Buchem 2014, p. 2) . Based on its contemporary practice the PLE is acknowledged to be a diffuse concept, thought to inherently represent the private and distinctive nature of its user.

Liew and Kang (2012) agreed with Attwell (2007) in stating that there is no consensus on a single PLE definition. Within contemporary research a PLE has been referred to as a system or a platform or even an approach to learning. Research abounds, investigating PLEs related to e-learning endeavors within formal educational institutions or considering the PLE as a replacement for the institutional learner management system (LMS) and/or as a specifically created single technological platform or tool (Fiedler and Våljataga 2013). However, the relative novelty of the PLE concept and the different ways of implementing, demands for more empirical research in order to validate the usefulness of students' PLEs in diverse informal settings.

Further, Fiedler and Våljataga (2013) stress that researchers appear to consider the PLE predominantly from a technology oriented perspective while a few studies, take a different perspective, viewing the PLEs predominantly as an educational concept (Valtonen et al. 2012; Castañeda and Soto 2010). For these researchers a PLE was not a software application or collection of tools, but more of a new method of using technologies for learning.

Consequently, in this study the PLE is viewed as a concept, recognized as a new approach to the use of digital technologies in learning (Gallego and Gamiz 2015). It is defined as comprising of all the different tools undergraduates use in their everyday life for learning (Attwell 2007). This definition reflects the core concepts of these environments: self-regulation and adaptation to personal needs (Kravcik and Klamma 2012), by including frequently used technologies and tools for providing a natural connection between formal and informal learning (Dabbagh and Kitsantas 2012).

### ***Digital Literacy (DL)***

A review of literacy related to digital technologies reveal many terms such as, digital literacy, Information Communication Technology (ICT) literacy, online literacy, multimedia literacy and new literacies (Bawden 2008; Knobel and Lankshear 2007).

While Eshet (2004) argues that the term 'digital literacy' is used in an erratic manner in the literature, Bawden (2008) indicates that digital literacy, is a very broad concept , not restricted to any particular skill set, technology form or information and is focusing on personal capabilities and attributes. Literature discusses several frameworks for modeling digital literacy, often criticized for not covering the full scope of the concept (Bennett 2014; Eshet 2012).

Digital literacy consists of: photo-visual literacy; reproduction literacy; branching literacy; information literacy; socio-emotional literacy and real-time thinking skill (Eshet 2012). It embraces technical, cognitive and social-emotional perspectives of online and offline learning with digital technologies (Ng 2012). The technical dimension includes having the relevant technical and operational skills to use digital technologies for learning. The cognitive dimension is associated with critical thinking applied to searching, evaluating and selecting information, digital tools and technologies for learning, while being knowledgeable about related ethical, moral and legal issues. The social-emotional dimension involves using online resources in a responsible manner, observing 'netiquette' such as showing respect while avoiding misinterpretation and misunderstanding and showing an awareness of privacy and individual safety concerns. Most digital literacy skills are developed outside formal education (Ferrari et al. 2012).

In keeping with these conceptualizations, digital literacy in this paper, refers to the collection of literacies associated with the usage of digital technologies. Technologies could include desktops, mobile devices (e.g.

laptops, tablets, smartphones, PDAs), Web 2.0 technologies and other collaborative resources on the internet as well as any open source or commercially available software packages.

We adopt Ng's (2012) digital literacy framework which consists of three interrelated dimensions: (i) technical (ii) cognitive and (iii) social-emotional; to underpin our conceptualization of digital literacy. This framework effectively draws together the broad definitions of digital literacy present in literature (Bawden 2008), while imbuing the varying literacy concepts referred to above. It has particular value because of its emphasis on different types of digital literacies envisioned as undergraduates' skills, which is the main focus of our study. Further, it is in keeping with our own conception of DL as skills that students autonomously acquire outside formal education via the use of a PLE.

The operationalization of the DL construct will be discussed in more detail in the methodology section.

### ***Self-Regulated Learning (SRL)***

Self-Regulated Learning (SRL) is defined as self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal learning goals (Zimmerman 2000). It is stated that the component skills include: (a) goal setting, (b) determining and implementing good strategies for realizing the goals, (c) monitoring performance consistently for improvement, (d) reorganization of one's physical and social environment to be attuned with one's goals, (e) efficient time management, (f) appraising one's methods and related results, and (g) acclimating future methods (Zimmerman 2002).

SRL has been one of the main objectives of formal education as set by researchers (Huang et al. 2013). Moreover, contemporary research acknowledges SRL to be a core skill for students to succeed in informal learning environments (Bembenutty 2011; Boekaerts and Minnaert 1999).

The use of technology is acknowledged to foster self-regulated learning in higher education contexts (Dabbagh and Kitsantas 2012; Dettori and Persico 2010; Salter 2013). Furthermore, even though the psychological and pedagogical theories around SRL precede the dawn of the PLE, SRL is regarded as an essential characteristic of the PLE. Consequently, SRL is supported within the PLE through gathering independent resources in a manner that realizes an explicit learning goal. The PLE, therefore, allows learners to regulate their own learning, hence augmenting their learning outcomes (Fruhmann et al. 2010; Henri et al. 2009).

As indicated by Santoso et al. (2014) the various SRL models share common features in: (i) planning, (ii) cognitive, (iii) monitoring, and (iv) regulating strategies. Planning is the process of selecting appropriate strategies and allocating resources that affect an individual's learning performance. Learners implement plans by engaging in explicit cognitive strategies or actions which depend strongly on learning context to accomplish their learning objectives. Learners must be able to monitor their learning progress to guarantee that cognitive actions produce learning. Regulating strategies are the actions taken by students as a result of what they achieved during learning.

Measuring self-regulation in learning involves the process of assessing how well students have developed the inclusive array of skills mentioned above. Several well-known researchers have proposed different models or frameworks of SRL and established methods for measurement of self-regulated learning amongst university students (e.g., Butler and Cartier 2005; Pintrich 2004; Zimmerman 1989).

The aforementioned four common features of SRL, can be measured through the use of the Academic Self-Regulated Learning Scale (A-SRL-S) (Magno 2010). This is a self-report measure based on the conceptualization and factors of the SRL framework by Zimmerman and Martinez-Pons (1988). As such it successfully addresses all features shared across often used multiple SRL models and is deemed suitable to represent the SRL construct as applicable in this research.

This scale, and its relevance to this study will be discussed in more detail in the methodology section of this paper.

## **Digital Literacy and Self-Regulated Learning – Interrelationship**

Present day students grow up in an environment, where concurrent media use of audio and visual devices as well as Web-enabled computers and mobile devices is required. The ability, therefore, to remain attentive, motivated, and engaged in learning tasks (i.e. self-regulatory abilities for learning) is very important (Liew et al. 2010). For university students being digitally literate by possessing a working knowledge of digital technology and understanding its usage for learning must be accompanied by strategies that promote, self-regulated learning, among other aspects (Azevedo 2007). Aspects of self-regulation in learning are also thought to be component skills in some digital literacy definitions, indicating that in order to develop DL skills SRL skills are instrumental (Janssen et al. 2013 ; Shopova 2014).

Jung and McMahon (2012) detail a successful experiment to ensure that digital literacies were promoted as part of a larger focus on students' self-regulation via redesigning an existing core learning unit for undergraduate students, based on the skill framework proposed by Eshet (2012). Via multiple studies and analyses of students' verbalized thoughts about the learning process, over thirty specific micro-level SRL processes that students enact while learning with computer based digital tools have been documented (Greene and Azevedo 2010; Greene et al. 2014). Research suggests that students who are effective at self-regulating their learning will continue to capitalize on the opportunities of computer based multimedia environments while those who lack this ability will find themselves at a serious disadvantage (Greene et al. 2011).

Moreover, current literature indicates that the use of technology impacts how SRL skills are developed and nurtured by investigating how the use of a particular technology can effect SRL. For example Goh et al. (2012) examined the effect of short messaging service (SMS) on the SRL strategies of undergraduates' using the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1993). They discovered that the peer learning and help seeking aspects of resource management SRL strategies had been improved for the experiment group while the time and study environment management dimension of MSLQ had been considerably lowered for the control group who received no SMS intervention. Kauffman et al. (2011), examined the particular instructional approaches of self-monitoring and note taking that can be used in web-based environments to improve undergraduates' SRL skills. This study found that students who used online note taking tools were at significant information selection and achievement advantages as compared to students who used conventional methods.

Consequently it is clear that the use of digital technologies and the skills used and developed via their use, does have a theoretical relationship with self-regulated learning which has been acknowledged by contemporary researchers, conducting research within the formal classroom. SRL, therefore, is an appropriate conceptual lens with which to view the manner in which undergraduates interact with technology for learning purposes. Moreover, while some PLE researchers are inclined to create an association to self-regulation either as a required competence for developing an individuals' PLE or as a skill set that is developed via the process of creating a PLE, there is little research that place an explicit focus on self-regulation within an informal PLE.

Following these observations of prior researchers, we propose that a bidirectional relationship exists between the constructs of DL and SRL, where each significantly impacts the other, within the context of undergraduates' use of a technology based informal PLE.

However most studies, when investigating this relationship, employed an experimental approach where a given technology was imposed on the students, and did not investigate how their current technological portfolio being used in daily life (i.e. everyday technologies) could have or is having an impact on their SRL skills. The generalizability of the above findings of studies conducted in the formal classroom to an informal learning context is also limited. Therefore there is a lack of empirical evidence regarding how technology use affects SRL skills of students when learning within informal settings via the construction of PLEs. There is also a need to understand the self-regulatory processes of students engaged in the use of such learning environments.

The following section details the methodology we propose to use in order to investigate these observations.

## Methodology

We adopt a mixed methods research approach for this study. It is deemed the most suitable to address our research question which calls for verification of hypothesis as well as real-life contextual understandings of the processes of learning with the aid of technology. Furthermore, literature indicates that the use of mixed methods provides increased credibility and usefulness for practitioners (Creswell 2014). This approach also fits the pragmatic world view of the researcher where the focus is on the consequences of this study and where questions are considered more important than methods. Pragmatism has been identified as the 'best' worldview for mixed methods research (Tashakkori and Teddlie 2010). As yet, there is no distinct list of mixed methods design options, enabling the development of a design that answers research questions within the limitations and boundaries of individual studies (Malina et al. 2010).

We have designed an explanatory, sequential study where the data collection will be done using quantitative and qualitative methods, as depicted in table 1 below. The qualitative strand is given priority. The quantitative methods will be used in a secondary role to supplement the findings. Interaction of strands will occur at data collection for sample selection and for triangulation at the analysis and interpretation stages.

<b>Table 1. Overview of Data Collection Techniques</b>			
Technique	Purpose	Sample	Construct Measured From figure 1
Technology use and Digital Literacy Questionnaire - Web based	Self-report measure on frequency of technology use, level of usage, perception of usefulness, proficiency levels, digital skill development methods and scores for technological, cognitive and social emotional literacy.	A proportionate purposive sample of stage 1 and stage 2 students enrolled in courses within the Business and Arts faculties.	DL and PLE
Academic Self-Regulated Learning Questionnaire - Web based	Self-report measure of the level of SRL skills.	Consecutive stratified sample of all respondents of the first survey, who indicated positive interest in further participation in data collection.	SRL
Face to face semi structured Interview	Description of actual usage of technology for learning within informal contexts. Assess past knowledge, opinions, conceptions and self-awareness of SRL and DL skills of the students, within their PLE.	Judgmental convenience sample of respondents from the second survey representative of the stage 1 and stage 2 strata.	DL and SRL
Academic Performance Data from the university internal learner management system	Understand the manner in which current self-reported SRL skill levels reflect in student performance at learning tasks.	Assessment and performance related information on key courses that they are enrolled in, for all the interviewed students.	SRL

**Table 1. Data Collection Techniques**

The population used for the study will be Stage 1 and 2 students enrolled in courses in the Business School and Arts faculty of a top university in the Asia-Pacific region. In targeting students enrolled in technology oriented business courses it is assumed that the profile of the students within this sample will broadly fit the description of a learner who is more interested in using everyday technology for learning purposes. To eliminate bias and improve generalizability, we also include Arts students who may not be as ready for the adoption of such technologies for learning.

The first survey, consists of closed ended and Likert scale type of questions from previously validated surveys for the purpose of measuring digital immersion levels of students together with their DL skills. DL, is represented as shown in Figure 1, by a three factor structure based on the instrument used by Ng (2012), consisting of technical literacy (6 items), cognitive literacy (2 items), social emotional literacy (2 items). Attitude towards technology use in learning is measured based on 9 items from Ng (2012) and Wolstenholme (2012). The survey also measures frequency of technology use, level of usage and approaches to digital skills development (adapted from Smith and Caruso 2010), proficiency levels in technology use (adapted from Wozney et al. 2006) and usage ratings and perceptions of usefulness of various technologies for learning tasks (adapted from Yakin and Gencel 2013)

The questions from multiple surveys had been included here and some minor modifications made to make the questions more suitable for the target population. Therefore, to ensure face and internal validity as well as consistency, a pilot test was conducted among 15 stage 1 and 2 undergraduate students, 5 postgraduate students and 1 academic staff member before it was released via email to the target population.

While the use of an established survey would strengthen construct validity for the DL construct we will also start to establish convergent validity for DL, using correlation. The same first survey will also provide scores for usage of various technologies in the individuals' PLE. In ensuring internal validity of our study, we will be using correlational methods to start to establish convergent validity for the PLE construct. We then plan to use confirmatory factor analysis to check discriminant validity for DL and PLE.

The second survey uses the seven factor structure from the A-SRL scale (Magno 2010). It measures memory strategy (14 items), goal-setting (5 items), self-evaluation (12 items), seeking assistance (8 items), environmental structuring (5 items), learning responsibility (5 items), and organizing (6 items).

The A-SRL scale was originally developed, used and proved with college students and allows measurement of SRL behavioral strategies. Unlike other measures for SRL which focus primarily on motivation (e.g. Pintrich et al. 1993), the focus of this instrument is situation specific SRL behaviors, as suitable for this study. The internal consistencies for the seven factors range from .73 to .87. Convergent validity, predictive validity and construct validity is well established in previous studies (Roth et al. 2015). Using a self-report instrument here, also allows us to view key variables through the eyes of actual students, which can capture data that an outside observer may miss.

However in addressing validity issues arising from using self-report measures, we assume that the participants, have the ability to verbally understand and report their thoughts and feelings. But this may not always be the case and can lead to measurement error (Roth et al. 2015)

SPSS AMOS 18 will be used for analysis of the quantitative data originating from the surveys via Structural Equation Modelling (SEM), correlational and regression analysis techniques in an attempt to validate our hypothesized bidirectional relationship between student's self-reported SRL skills and digital literacy.

The interviews will enable interviewees to voice their detailed opinions regarding technology use for learning, providing information about learners' experiences by inquiring on retrospective or prospective behavior. Before arriving, the interviewees are asked to complete a mind map of how they use technological tools and devices to learn. This mind map will provide us with a list of tools and technologies the interview participants use to create their PLEs while giving indications of how the technologies have been adopted for learning. However this will be a current snapshot of the various PLEs used by them, bounded by technological constraints as applicable to the current undergraduates. Moreover, it is seen that initial completion of mind maps can aid in identifying unique concepts and providing more in-depth responses about their experience in the subsequent interview (Wheeldon 2011).

Moreover, in light of arguments that self-report measures alone are not adequate to obtain a clear indication of SRL (see Greene and Azevedo 2010; Schraw 2010) and in keeping with the arguments of Turner (2006) who stressed on the importance of obtaining a more complete and contextual view of self-regulation; we



believe that the A-SRL instrument alone would not provide an adequate answer to the research question, nor an accurate measurement of SRL. The use of multiple complementary tools in addition to self-report questionnaires to measure SRL as an intricate, situated, changing process capturing individual learning in context, is recommended in literature.

We intend to act on these recommendations during the interviews conducted with the research participants. Therefore, while questioning reflection on self-regulated learning behavior, we also intend to guide the structure of this interview based on the Self-Regulated Learning Interview Schedule (SRLIS) (Zimmerman and Martinez-Pons (1988). The SRLIS is originally designed to assess students' SRL strategy use in classroom and non-classroom contexts. However, our questions will focus specifically on informal learning contexts, in providing descriptions of technology related learning tasks and asking students to describe in detail the self-regulation method they use in each situation in an open ended question.

We propose engaging in a thematic analysis of the interview data, to be coded and analyzed using NVIVO 11. The aim is to arrive at description and conceptualization of technology usage levels, perception of usefulness, proficiency levels, digital skill development methods and SRL strategies to help explain the interrelationship between DL and SRL skills of the participants.

We propose to obtain performance information for participants on key courses to track how learners engage in particular tasks within context as recommended by Butler and Cartier (2005). This is done in order to obtain an insight in to how well these students perform academically, to enhance the richness of the data collected via the other techniques. This will provide a different facet to this investigation and enhance our understanding of the consequences of the SRL processes the students engage in, especially in light of arguments within literature that students with higher levels of SRL skills perform better from an academic perspective (Cheng 2011).

## **Expected Contributions and Outlook**

This paper suggests that present-day undergraduates are autonomously learning the instrumental digital skills and knowledge via the use of their own personalized learning environments (PLE). It also suggests that the use of such PLEs have an influence on the SRL skills demonstrated by these students in academic tasks, while self-regulation strategies themselves may also influence DL skill acquisition and development.

We are presently gathering data for the first self-reported measure (discussed in table 1) to understand the DL skill levels of students and the usage levels of various technologies used for creating their PLE. Our preliminary findings should be ready soon. We are currently engaged in a cluster analysis of the survey results to categorize the survey participants based on their self-reported frequency of technology use, level of usage, perception of usefulness and perceived proficiency levels with technology. We will then be obtaining the consecutive samples for the subsequent data collection activities.

The shortcomings of using a self-report measure here could be mitigated by user observations in experiments, which could be applied in future research. Further, longitudinal measures could provide a more exhaustive understanding of SRL strategies beyond the single self-reported measures of SRL proposed here. However, we hope to mitigate this by investigating the qualitative data as described above.

The theoretical contribution of our study is the holistic consideration of the interplay between DL and SRL, to elaborate on its context and significance by applying a mixed-methods research approach. We believe that empirical evidence from this study would contribute towards creating a more precise picture of the patterns and contexts of technology adoption by university students, and the resultant impact on their learning skills. It will specifically clarify the interplay between the DL skills of undergraduates and their SRL skills, how one may be influencing the other and vice versa, enriching the literature on both DL and SRL. On a more practical footing, deriving insights from our completed research, will enumerate the interaction between informal technology use and the transfer of relevant technological and learning skills to formal classroom use, contributing empirical evidence to the ongoing discussion of novel models of learning.

## References

- Atkins, L., Fraser, J., and Hall, R. 2013. *DigiLit Leicester: 2013 Survey Results*, Leicester: Leicester City Council (CC BY-NC 3.0).
- Attwell, G. 2007. "Personal Learning Environments-the future of eLearning?," *eLearning papers* (2:1), pp. 1–8.
- Azevedo, R. 2007. "Understanding the complex nature of self-regulatory processes in learning with computer-based learning environments: an introduction," *Metacognition and Learning* (2:2–3), pp. 57–65 (doi: 10.1007/s11409-007-9018-5).
- Balcikanli, G. S. 2012. "Social Networking in Physical Education: Undergraduate Students' Views on Ning," *Turkish Online Journal of Distance Education* (13:2), pp. 277–290.
- Bawden, D. 2008. "Origins and concepts of digital literacy," in *Digital Literacies: Concepts, Policies and Practices*, New York: Peter Lang.
- Bembunty, H. 2011. "New directions for self-regulation of learning in postsecondary education," *New Directions for Teaching and Learning* (2011:126), pp. 117–124 (doi: 10.1002/tl.450).
- Bennett, L. 2014. "Learning from the early adopters: developing the digital practitioner," *Research in Learning Technology* (22:0) (doi: 10.3402/rlt.v22.21453).
- Boekaerts, M., and Minnaert, A. 1999. "Self-regulation with respect to informal learning," *International Journal of Educational Research* (31:6), pp. 533–544.
- Buchem, I. 2014. "Editorial for the Special Issue on Personal Learning Environments," *Special Edition: Personal Learning Environments: Current Research and Emerging Practice Journal of Literacy and Technology* (15:2).
- Bullen, M., Morgan, T., and Qayyum, A. 2011. "Digital learners in higher education: Generation is not the issue," *Canadian Journal of Learning and Technology/La revue canadienne de l'apprentissage et de la technologie* (37:1) (available at [http://www.editlib.org/p/42755/article\\_42755.pdf](http://www.editlib.org/p/42755/article_42755.pdf)).
- Butler, D. L., and Cartier, S. C. 2005. "Multiple complementary methods for understanding self-regulated learning as situated in context," in *Meetings of the American Educational Research Association*.
- Castañeda, L., and Soto, J. 2010. "Building Personal Learning Environments by Using and Mixing ICT Tools in a Professional Way," *Digital Education Review* (18), pp. 9–25.
- Chatti, M. A., Agustiawan, M. R., Jarke, M., and Specht, M. 2010. "Toward a Personal Learning Environment Framework," *International Journal of Virtual and Personal Learning Environments* (1:4), pp. 66–85 (doi: 10.4018/jvple.2010100105).
- Cheng, C. K. E. 2011. "The role of self-regulated learning in enhancing learning performance," *The International Journal of Research and Review* (6:1) (available at <http://libir1.ied.edu.hk/dspace/handle/2260.2/11807>).
- Conole, G. 2012. "Open, Social and Participatory Media," in *Designing for Learning in an Open World Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*, Springer New York, pp. 47–63 (available at [http://link.springer.com/chapter/10.1007/978-1-4419-8517-0\\_4](http://link.springer.com/chapter/10.1007/978-1-4419-8517-0_4)).
- Costa, F. A., Cruz, E., and Viana, J. 2010. "Managing personal learning environments: the voice of the students," in *The PLE Conference, The PLE Conference*, pp. 1–12.
- Creswell, J. W. 2014. *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed.), Thousand Oaks: SAGE Publications.
- Dabbagh, N., and Kitsantas, A. 2012. "Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning," *The Internet and Higher Education Social Media in Higher Education* (15:1), pp. 3–8 (doi: 10.1016/j.iheduc.2011.06.002).
- Dahlstrom, E., and Bichsel, J. 2014. "ECAR study of undergraduate students and information technology 2014," Louisville, CO: ECAR: EDUCAUSE (available at <http://www.csus.edu/irt/cio/strategicplanning/Documents/Undergrad-Students-and-IT-2014-Full-Report.pdf>).
- Dettori, G., and Persico, D. (Eds.). 2010. *Fostering Self-Regulated Learning through ICT*, IGI Global (available at <http://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-61692-901-5>).
- Ensminger, D. C., and Lewis, J. 2011. "Technology in Higher Education: Understanding Student Issues," in *Technology Integration in Higher Education: Social and Organizational Aspects*, IGI Global, pp. 30–41 (available at <http://www.igi-global.com/chapter/technology-higher-education/51447>).

- Eshet, Y. 2004. "Digital Literacy: A Conceptual Framework for Survival Skills in the Digital era," *Journal of Educational Multimedia and Hypermedia* (13:1), pp. 93–106.
- Eshet, Y. 2012. "Thinking in the digital era: A revised model for digital literacy," *Issues in Informing Science and Information Technology* (9:2), pp. 267–276.
- Ferrari, A. 2012. "Digital Competence in practice: An analysis of frameworks," Seville: JRC-IPTS (available at [http://jiscdesignstudio.pbworks.com/w/file/fetch/55823162/FinalCSReport\\_PDFPARAWEB.pdf](http://jiscdesignstudio.pbworks.com/w/file/fetch/55823162/FinalCSReport_PDFPARAWEB.pdf)).
- Fiedler, S. H. D., and Våljataga, T. 2011. "Personal Learning Environments: Concept or Technology?," *International Journal of Virtual and Personal Learning Environments* (2:4), pp. 1–11 (doi: 10.4018/jvple.2011100101).
- Fiedler, S. H., and Våljataga, T. 2013. "Personal learning environments: a conceptual landscape revisited," *eLearning Papers* (35), pp. 1–16.
- Fruhmman, K., Nussbaumer, A., and Albert, D. 2010. "A psycho-pedagogical framework for self-regulated learning in a responsive open learning environment," in *Proceedings of the International Conference eLearning Baltics Science (eLBA Science 2010)*, Fraunhofer, pp. 1–2 (available at <http://css-kti.tugraz.at/research/cssarchive/staff/nussbaumer/pubfiles/ELBA2010-SRLFramework.pdf>).
- Gallego, M. J., and Gamiz, V. M. 2015. "Personal Learning Environments (PLE) in the Academic Achievement of University Students," *Australian Educational Computing* (29:2) (available at <http://journal.acce.edu.au/index.php/AEC/article/view/30>).
- Goh, T., Seet, B., and Chen, N. 2012. "The impact of persuasive SMS on students' self-regulated learning: The impact of persuasive SMS on students' self-regulated learning," *British Journal of Educational Technology* (43:4), pp. 624–640 (doi: 10.1111/j.1467-8535.2011.01236.x).
- Greene, J. A., and Azevedo, R. 2010. "The Measurement of Learners' Self-Regulated Cognitive and Metacognitive Processes While Using Computer-Based Learning Environments," *Educational Psychologist* (45:4), pp. 203–209 (doi: 10.1080/00461520.2010.515935).
- Greene, J. A., Moos, D. C., and Azevedo, R. 2011. "Self-regulation of learning with computer-based learning environments," *New Directions for Teaching and Learning* (2011:126), pp. 107–115 (doi: 10.1002/tl.449).
- Greene, J. A., Yu, S. B., and Copeland, D. Z. 2014. "Measuring critical components of digital literacy and their relationships with learning," *Computers & Education* (76), pp. 55–69 (doi: 10.1016/j.compedu.2014.03.008).
- Henri, F., Charlier, B., and Limpens, F. 2009. "Understanding and supporting the creation of more effective PLE," in *Int. Conf. on Information Resources Management*, Dubai, Dubai, UAE (available at <http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1031&context=confirm2009>).
- Huang, Y.-M., Chao, H.-C., Deng, D.-J., and Park, J. J. J. H. 2013. *Advanced Technologies, Embedded and Multimedia for Human-centric Computing: HumanCom and EMC 2013*, Springer Science & Business Media.
- Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., and Sloep, P. 2013. "Experts' views on digital competence: Commonalities and differences," *Computers & Education* (68), pp. 473–481 (doi: 10.1016/j.compedu.2013.06.008).
- Johnson, L., Estrada, V., Adams Becker, S., and Freeman, A. 2015. *NMC Horizon Report: 2015 Higher Education Edition*, Austin Texas; [S.l.]: New Media Consortium ; EDUCAUSE Learning Initiative.
- Jung, J. H., and McMahan, M. 2012. "Press Any Key: Repositioning digital literacy as an enabler for self-regulated learning," (Vol. 2012), Presented at the *World Conference on Educational Media and Technology*, June 26, pp. 632–637 (available at <http://www.editlib.org/p/40812/>).
- Kabilan, M. K., Ahmad, N., and Abidin, M. J. Z. 2010. "Facebook: An online environment for learning of English in institutions of higher education?," *The Internet and Higher Education Special Issue on Web 2.0* (13:4), pp. 179–187 (doi: 10.1016/j.iheduc.2010.07.003).
- Kauffman, D., Zhao, R. M., and Yang, Y. 2011. "Effects of online note taking formats and self-monitoring prompts on learning from online text: Using technology to enhance self-regulated learning," *Contemporary educational psychology* (36:4), pp. 313–322.
- Keppell, M. J. 2015. "The Learning Future: Personalised Learning in an Open World," in *MOOCs and Open Education Around the World*, Routledge.
- Knobel, M., and Lankshear, C. (Eds.). 2007. *A new literacies sampler New literacies and digital epistemologies*, New York: P. Lang.
- Kravcik, M., and Klamma, R. 2012. "Supporting self-regulation by personal learning environments," in *Advanced Learning Technologies (ICALT), 2012 IEEE 12th International Conference on*, IEEE, pp. 710–711 (available at [http://ieeexplore.ieee.org/xpls/abs\\_all.jsp?arnumber=6268230](http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6268230)).

- Laakkonen, I., and Taalas, P. 2015. "Towards new cultures of learning: Personal learning environments as a developmental perspective for improving higher education language courses," *Language Learning in Higher Education* (5:1) (doi: 10.1515/cercles-2015-0011).
- Liew, B. T., and Kang, M. 2012. "Personal Learning Environment for Education: A Review and Future Directions," in *New Horizons in Web Based Learning Lecture Notes in Computer Science*, D. K. W. Chiu, M. Wang, E. Popescu, Q. Li, and R. Lau (eds.), Springer Berlin Heidelberg, pp. 30–38 (available at [http://link.springer.com/chapter/10.1007/978-3-662-43454-3\\_4](http://link.springer.com/chapter/10.1007/978-3-662-43454-3_4)).
- Liew, J., Chang, Y., Kelly, L., and Yalvac, B. 2010. "Self-regulated and social emotional learning in the multitasking generation," in *How Do Children Learn Best*, Ankara, Turkey: Children's Research Center: D. Sahnuseyinoglu & D. Ilisko (Eds.), pp. 62–70 (available at <http://projectabc.tamu.edu/sites/projectabc.tamu.edu/files/Liew%20et%20al%20-%20Self-regulated%20and%20social%20emotional%20learning%20in%20the%20multitasking%20generation%202010.pdf>).
- Lowe, B., and Laffey, D. 2011. "Is Twitter for the Birds? Using Twitter to Enhance Student Learning in a Marketing Course," *Journal of Marketing Education* (33:2), pp. 183–192 (doi: 10.1177/0273475311410851).
- Magno, C. 2010. "Assessing academic self-regulated learning among Filipino college students: The factor structure and item fit," *The International Journal of Educational and Psychological Assessment* (5) (available at [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2287208](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2287208)).
- Malina, M. A., Norreklit, H., and Selto, F. H. 2010. "Lessons Learned: Advantages and Disadvantages of Mixed Methods Research," SSRN Scholarly Paper No. ID 1826304, Rochester, NY: Social Science Research Network (available at <http://papers.ssrn.com/abstract=1826304>).
- Margaryan, A., Littlejohn, A., and Vojt, G. 2011. "Are digital natives a myth or reality? University students' use of digital technologies," *Computers & Education* (56:2), pp. 429–440 (doi: 10.1016/j.compedu.2010.09.004).
- Melzer, P., and Schoop, M. 2015. "A Conceptual Framework for Task and Tool Personalisation in IS Education," in *ICIS 2015 Proceedings*, Presented at the Thirty Sixth International Conference on Information Systems, Fort Worth, December 13 (available at <http://aisel.aisnet.org/icis2015/proceedings/ISedu/6>).
- Mikroyannidis, A., and Connolly, T. 2012. "Chapter 02. Introducing Personal Learning Environments to informal learners: lessons learned from the OpenLearn case study | Open Educational Resources," *Open Educational Resources and Social Networks* (available at [http://oer.kmi.open.ac.uk/?page\\_id=1254#.VYzLgfmqBc](http://oer.kmi.open.ac.uk/?page_id=1254#.VYzLgfmqBc); retrieved June 26, 2015).
- Mohd, C. K. N. C. K., and Shahbodin, F. 2015. "Personalized Learning Environment (PLE) Experience in the Twenty-First Century: Review of the Literature," in *Pattern Analysis, Intelligent Security and the Internet of Things Advances in Intelligent Systems and Computing*, A. Abraham, A. K. Muda, and Y.-H. Choo (eds.), Springer International Publishing, pp. 179–192 (available at [http://link.springer.com/chapter/10.1007/978-3-319-17398-6\\_17](http://link.springer.com/chapter/10.1007/978-3-319-17398-6_17)).
- Ng, W. 2012. "Can we teach digital natives digital literacy?," *Computers & Education* (59:3), pp. 1065–1078 (doi: 10.1016/j.compedu.2012.04.016).
- Pettenati, M. C. 2010. "Roadmap to PLE - A Research Route to Empower the Use of Personal Learning Environments (PLEs)," *Interaction Design and Architecture(s)* (9–10), p. 11.
- Pintrich, P. 2004. "A Conceptual Framework for Assessing Motivation and Self-Regulated Learning in College Students," *Educational Psychology Review* (16:4), pp. 385–407.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., and Mckeachie, W. J. 1993. "Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (Mslq)," *Educational and Psychological Measurement* (53:3), pp. 801–813 (doi: 10.1177/0013164493053003024).
- Roth, A., Ogrin, S., and Schmitz, B. 2015. "Assessing self-regulated learning in higher education: a systematic literature review of self-report instruments," *Educational Assessment, Evaluation and Accountability*, pp. 1–26 (doi: 10.1007/s11092-015-9229-2).
- Salter, P. 2013. "Helping or Hindering? Technology's Impact on Secondary Students' Self-Regulated Learning," in *World Conference on Educational Multimedia, Hypermedia and Telecommunications* (Vol. 2013), pp. 2271–2280 (available at <http://www.editlib.org/p/112288/>).
- Santoso, H. B., Lawanto, O., Becker, K., Fang, N., and Reeve, E. M. 2014. "High and Low Computer Self-Efficacy Groups and Their Learning Behavior from Self-Regulated Learning Perspective While Engaged in Interactive Learning Modules," *Journal of Pre-College Engineering Education Research (J-PEER)* (4:2).

- Schraw, G. 2010. "Measuring Self- Regulation in Computer- Based Learning Environments," *Educational Psychologist* (45:4), pp. 258–266.
- Shopova, T. 2014. "Digital Literacy of Students and Its Improvement at the University," *Journal on Efficiency and Responsibility in Education and Science* (7:2), pp. 26–32 (doi: 10.7160/eriesj.2014.070201).
- Siemens, G., Gasevic, D., and Dawson, S. 2015. *Preparing for the digital university: a review of the history and current state of distance, blended, and online learning*, MOOC Research Initiative.
- Smith, S., and Caruso, J. 2010. "ECAR Study of Undergraduate Students and Information Technology, 2010 | EDUCAUSE.edu," Research Report, EDUCAUSE Center for Analysis and Research (ECAR) (available at <http://www.educause.edu/library/resources/ecar-study-undergraduate-students-and-information-technology-2010>).
- Steffens, K. 2007. "Self-regulated learning in technology enhanced learning environments: a European review," *Self-regulated Learning in Technology Enhanced Learning Environments: Individual Learning and Communities of Learners*, p. 9.
- Steffens, K., and Underwood, J. 2008. "Introduction: Self-regulated learning in a digital world," *Technology, Pedagogy and Education* (17:3), pp. 167–170 (doi: 10.1080/14759390802383736).
- Tashakkori, A., and Teddlie, C. 2010. *SAGE Handbook of Mixed Methods in Social & Behavioral Research*, SAGE.
- Tausend, J. 2013. "How Students Use Technology Outside of the Classroom," *EdTech Magazine* (available at <http://www.edtechmagazine.com/higher/article/2013/08/how-students-use-technology-outside-classroom>; retrieved August 4, 2015).
- Tess, P. A. 2013. "The role of social media in higher education classes (real and virtual) – A literature review," *Computers in Human Behavior* (29:5), pp. A60–A68.
- Turner, J. C. 2006. "Measuring Self-Regulation: A Focus on Activity," *Educational Psychology Review* (18:3), pp. 293–296.
- Valtonen, T., Hacklin, S., Dillon, P., Vesisenaho, M., Kukkonen, J., and Hietanen, A. 2012. "Perspectives on personal learning environments held by vocational students," *Computers & Education* (58:2), pp. 732–739 (doi: 10.1016/j.compedu.2011.09.025).
- Vivian, R., and Barnes, A. 2010. "Social networking: from living technology to learning technology?," *Curriculum, Technology & Transformation for an unknown Future*, Proceedings Ascilite Sydney, pp. 1007–1019.
- Wheeldon, J. 2011. "Is a picture worth a thousand words? Using mind maps to facilitate participant recall in qualitative research," *The Qualitative Report* (16:2), p. 509.
- Wolstenholme, P. 2012. "The state of digital literacies within staff in higher education administration and management," Baseline report, , United Kingdom: Association of University Administrators (available at <http://jiscdesignstudio.pbworks.com/w/file/fetch/50442087/AUA%20baseline%20report.pdf>).
- Wozney, L., Venkatesh, V., and Abrami, P. 2006. "Implementing computer technologies: Teachers' perceptions and practices," *Journal of Technology and teacher education* (14:1), pp. 173–207.
- Yakin, I., and Gencil, I. E. 2013. "The Utilization of Social Media Tools for Informal Learning Activities: A Survey Study," *Mevlana International Journal of Education*, pp. 108–117 (doi: 10.13054/mije.13.54.3.4).
- Yang, M., and Kim, J. 2014. "Correlation between Digital Literacy and Self- Regulated Learning Skills of Learners in University E-Learning Environment," *ASTL Volume 71, 2014: Current Research on Education III* (available at [http://serisc.org/proceedings/vol71\\_2014.php](http://serisc.org/proceedings/vol71_2014.php); retrieved May 10, 2015).
- Zimmerman, B. J. 1989. "Models of Self-Regulated Learning and Academic Achievement," in *Self-Regulated Learning and Academic Achievement Springer Series in Cognitive Development*, B. J. Zimmerman and D. H. Schunk (eds.), Springer New York, pp. 1–25 (available at [http://link.springer.com/chapter/10.1007/978-1-4612-3618-4\\_1](http://link.springer.com/chapter/10.1007/978-1-4612-3618-4_1)).
- Zimmerman, B. J. 2000. "Chapter 2 - Attaining Self-Regulation: A Social Cognitive Perspective," in *Handbook of Self-Regulation* M. B. R. P. Zeidner (ed.), San Diego: Academic Press, pp. 13–39 (available at <http://www.sciencedirect.com/science/article/pii/B9780121098902500317>).
- Zimmerman, B. J. 2002. "Becoming a Self-Regulated Learner: An Overview," *Theory Into Practice* (41:2), p. 64.
- Zimmerman, B. J., and Martinez-Pons, M. 1988. "Construct validation of a strategy model of student self-regulated learning," *Journal of Educational Psychology* (80:3), pp. 284–290 (doi: 10.1037/0022-0663.80.3.284).